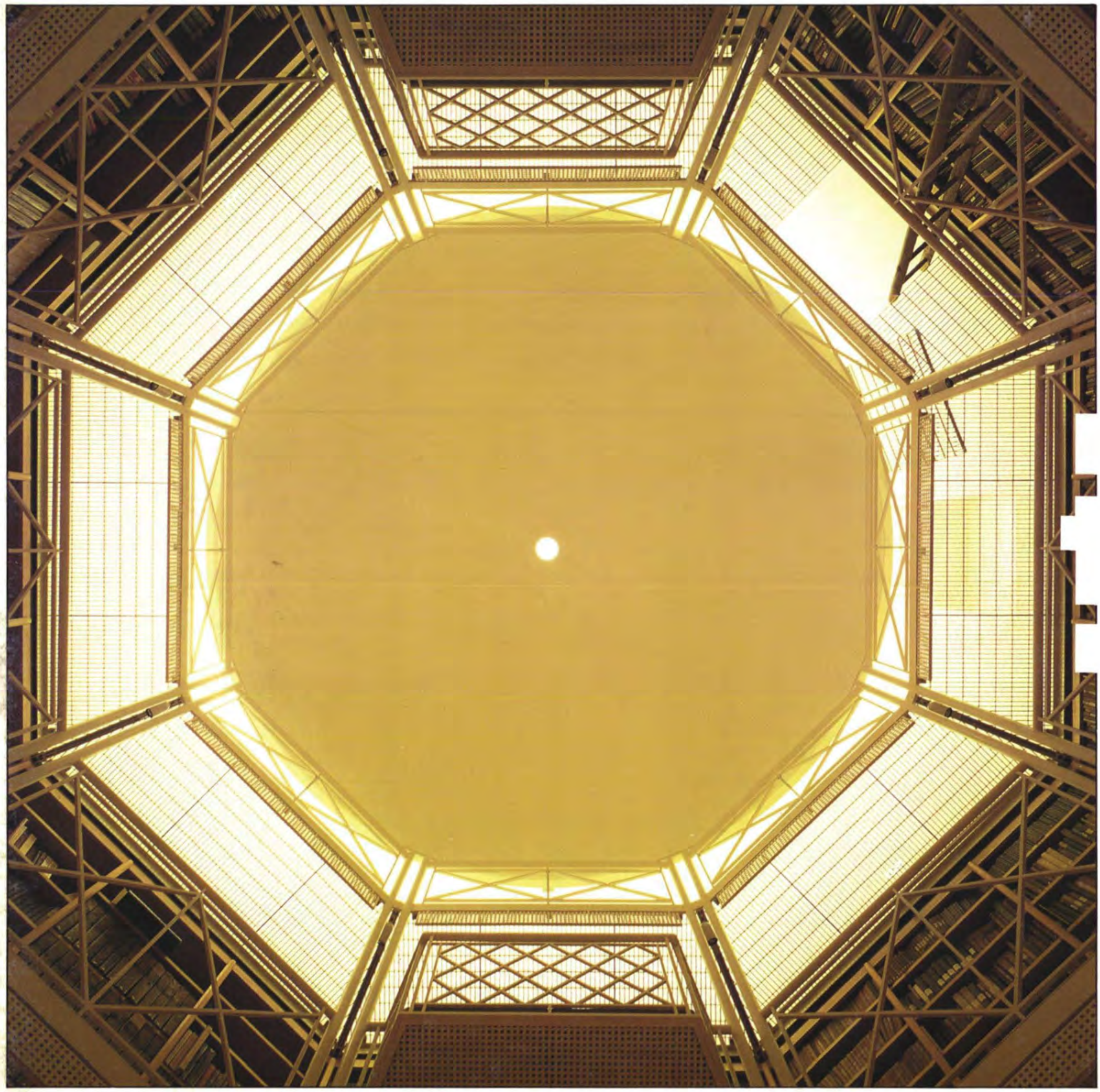
THE ARUP JOURNAL

AUTUMN 1987



THE ARUP JOURNAL

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Lord's Mound Stand

Architects: Michael Hopkins & Partners

John Thornton

Introduction

In January 1985 the MCC invited five architects to enter a competition for the design of a new stand to replace the Mound Stand, built by Frank Verity in 1898-99. The new stand, to be completed for the season of 1987, the bicentennial year, was to provide public seating, debenture seating and hospitality boxes with associated bars, kitchens, toilets and facilities for ground staff. Michael Hopkins and Partners, supported by Arups' Building Engineering Group 7, won the competition.

The design of the finished stand, which is little different in principle from that which won the competition, is seen as a number of layers. Each layer is based on a distinct principle, the most important of these being that of retaining the old Mound Stand and building a new structure over it.

This saved the cost and time of demolishing the old terrace and then replacing it with a new structure; it also had the incidental advantage of preserving a well-liked part of the ground.

The competition brief was written on the assumption that 18 months would be spent in design and off-site prefabrication before constructing the stand in a single closed season. Retaining and improving the old stand made it possible to spread construction over two seasons because of the short lead-time of refurbishment work.

The strategy was to remove the steel and asbestos-cement roof which was added in 1932, refurbish the terraces and the accommodation underneath, install the superstructure foundations and fix new seats in the first closed season so that the stand could be used in the next season. The remainder of the work would be carried out in the second closed season. It was also possible to carry out all the work in one closed season, if the MCC wished, because work below the terrace could carry on safely at the same time as the superstructure. The programme advantage was less, though, because the superstructure could not proceed until the foundations were complete.

Brief description

The stand consists of six layers (Fig. 1):

(1) Ground level accommodation in the brick structure under the terrace

(2) Terrace

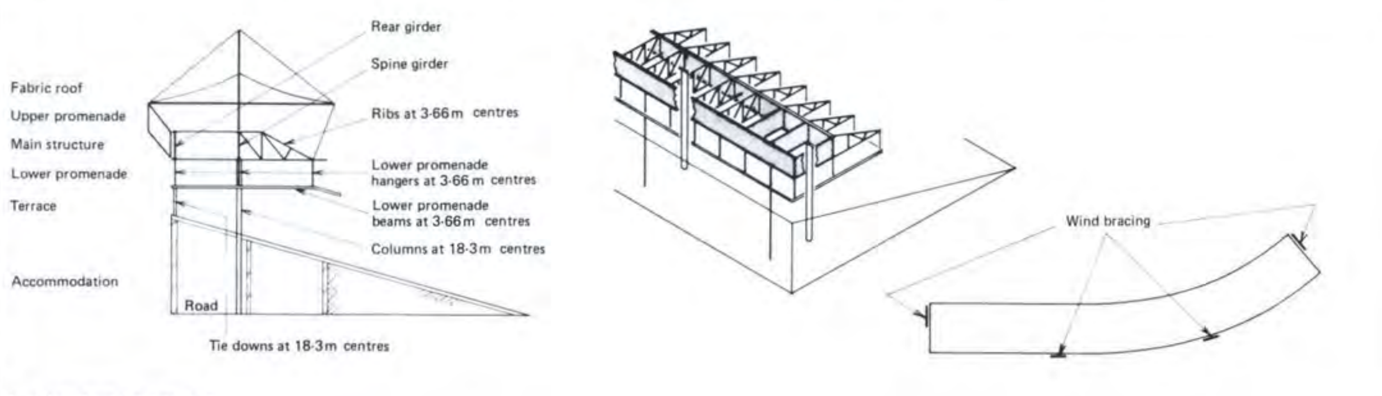
(3) Lower promenade with hospitality boxes and kitchens

(4) Main structural zone containing mezzanine floor with toilets, plant room and stores

(5) Upper promenade with debenture seats, restaurant and bars

(6) Fabric roof.

The superstructure of the stand is approximately 100m long and 12m wide; half of it is curved in plan.



1. Structural diagrams

2. Model of the competition entry
(Photo: The architects)

3. The beam system during construction
showing the new brick arches (Photo: Harry Sowden)

PHASE 1

In structural terms the old Mound Stand consisted of three zones: next to the pitch was a terrace of seating on the eponymous mound of clay, behind this the terrace was supported on a brick structure containing offices, shop, bar, canteen and toilets, behind this again was a roadway on the other side of which was the boundary wall. The terrace extended over the roadway for most of its length (Fig. 4).

The structure of the terrace in those areas where it was suspended consisted of steel beams with breeze concrete and T section filler joist infill. It was supported by steel columns where it extended to the boundary wall and was covered by the steel and asbestos-cement roof.

The wall of the curved part of the old stand comprised seven brick arches but these stopped at the point where the terrace extended over the roadway. There was no visual link between the arches and the undistinguished structure over the roadway. Moreover, there was a strange relationship between the existing terrace plan and that of the new stand above.

The solution to this was to demolish the boundary wall and to extend the arches over the length of the stand. The road was realigned so that it was contained behind the arches over its full length (Fig. 5). This not only dramatically improved the appearance but also gave the stand the constant cross-section it needed if it was to relate properly to the new structure. The colonnade, for the first time, lets the public see into the ground, although not, of course, the pitch.

Phase 1 work consisted of the following:

(1) Removing the old roof

(2) Installing piled foundations for the new arches along the back

(3) Installing piled foundations for Phase 2 columns, tie-downs and bracing

(4) Modifying steelwork to suit the rearrangement of supporting walls

(5) Repairing and modifying brickwork

(6) Repairing damaged areas of terrace

(7) Adding concrete to the lower area of the terraces to level them for fixed seating

(8) Replacing areas of terrace with reinforced concrete

(9) Renewing the asphalt waterproofing

(10) Providing new toilets and booster pump room

(11) Replacing and strengthening handrails and crush barriers.

When trial holes were cut in the terraces some of the filler joists were found to be badly corroded where the terrace waterproofing had leaked. The terraces were justified by ignoring the joists and showing that the steps could act as flat arches. The arch thrusts were resisted by new slabs at each end tied to the walls below.

PHASE 2
Steel structure

The concept for the superstructure is essentially the same as that of the competition entry (Fig. 1). It is a steel structure based on a spine beam supported by six columns at 18.3m centres. Rib beams at 3.66m centres cantilever to front and back from the spine. This is the module of the brick arches which, luckily, is that needed for the most efficient layout of the hospitality boxes on the lower promenade. The latter is suspended from the spine beam and the ends of the rib beams. The upper promenade is above the rib beams which slope at the front to give the necessary rake to the seats.

The weight is well-balanced over the columns with more weight to the front. Stability is provided by tying down to the ground along the back on the 18.3m grid. In extreme loading conditions the tie-downs can go into compression, particularly in the curved section where the areas behind and in front of the spine are respectively increased and reduced. They are therefore sized to act as struts as necessary; the buckling length is reduced by restraints to the lower terrace structure.

Unbalanced loads on individual ribs are distributed back to the column/tie-down system by a girder along the back.

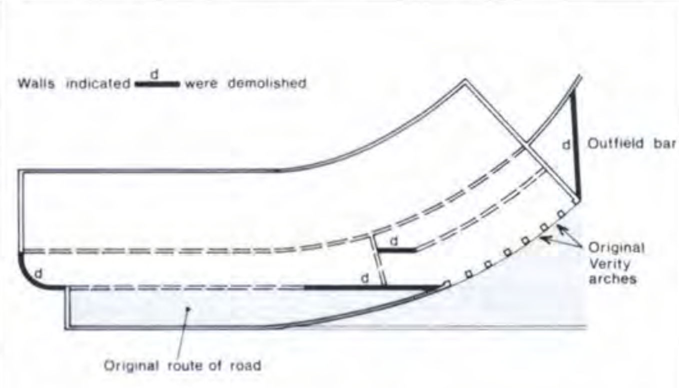
Stability against transverse forces is provided by additive cross-braced steel frames at each end while longitudinal stability is provided by bracing on the rear elevation which carries the forces down to terrace level (Fig. 1).

The main development after the competition was in the spine and rib system. It became clear that there was insufficient space on the two promenade levels for all the toilet and storage requirements. Also, the architect wanted to avoid 'cabins' on the upper promenade which would spoil the principle of this being a clear space under a canopy.

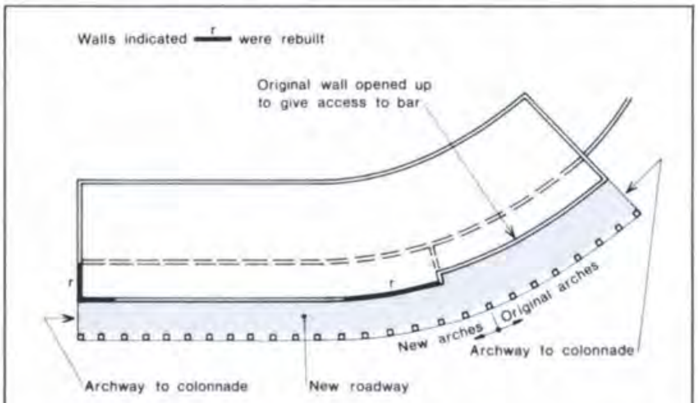
The solution to this problem was to increase the depth of the spine beam and change the profile of the rear ribs from triangular to rectangular, thus creating the space for a series of rooms within the structure.

This led directly to the idea of using plate girders rather than trusses for the spine beam, rear beam and ribs so that the walls would be formed by the steel of the structure. External vertical stiffeners on the exposed rear beam are on the 3.66m grid while horizontal stiffeners on the rear beam and end ribs reflect the rise of the seating. They are a key part of the architectural definition of these elements. However, negotiations with contractors showed that there would be a cost saving if the rib beams were to become trusses in those areas where they were not part of an enclosure. Thus in the final design the end ribs are plate girders as are the rear ribs which flank the staircases and toilets; the others are trussed.

There was concern that the underside of the lower promenade should not appear as a heavy lid over the spectators on the terrace. The primary structure consists of exposed steel beams on the 3.66m grid which help break up the soffit visually. Various forms of slab construction were considered including the use of ferrocement permanent forms but the final choice was for a simple *Omnidec* precast concrete plank with an in situ top-



4. Plan of terrace: old Mound stand



5. Plan showing realignment of road

ping. The soffits of these were given a broad-banded shallow relief pattern and the joints rebated to give a lightly modelled surface.

The floors of the mezzanine level within the primary structure and the level area of the upper promenade are of profiled metal deck with lightweight concrete topping while the stepped areas are of galvanized pressed metal steps with a granolithic concrete infill to the tops.

The bracing at the ends of the stand is made up in a gridded tubular panel system which allows access through in a systematic way.

It is connected to the end ribs by means of articulated plates which carry horizontal loads but allow the vertical deflection of the stand to take place without transmitting vertical load into the bracing.

It had been intended that there should be a single panel of cross-bracing in the centre at the rear which would allow thermal expansion to take place freely toward the ends. However, it was better architecturally for the bracing to be in the same bays as the two staircases, which created the potential for large forces to be generated by thermal expansion between the fixed points. This was avoided by using cables for the tension members; they were selected to have a balance of strength and stiffness such that they could carry the stability loads while being flexible enough to allow the thermal expansion to take place without large forces.

The greater part of the horizontal loads on the structure acts at the upper promenade level. The width of the slab here is limited to 8m by the debenture seating steps and so it is considerably less stiff, when spanning from end to end, than the 12m wide lower promenade slab. The forces are transferred from upper to lower promenade through cross-braced panels either side of the two internal staircases. A horizontal steel strut/tie across each stair opening maintains the 12m effective depth of the lower promenade slab. The passenger lift is adjacent to the west end of the stand and connected to it by a steel staircase. The plate girder theme was carried through to the lift shaft which is a stiffened steel box.

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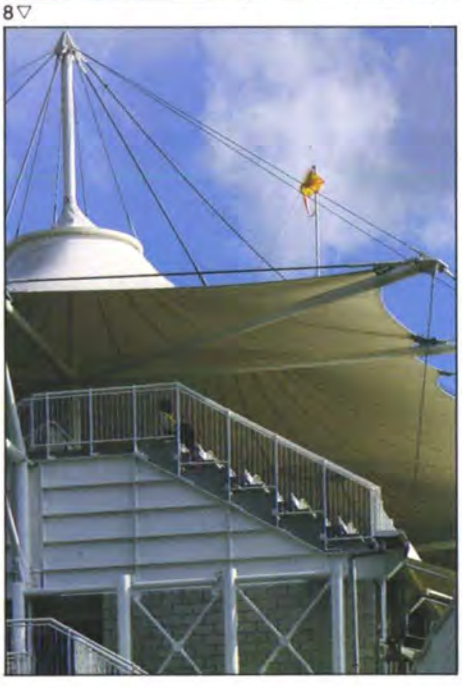

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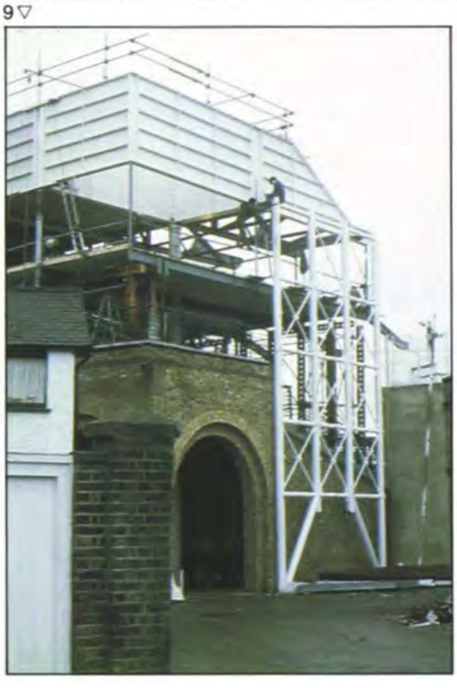

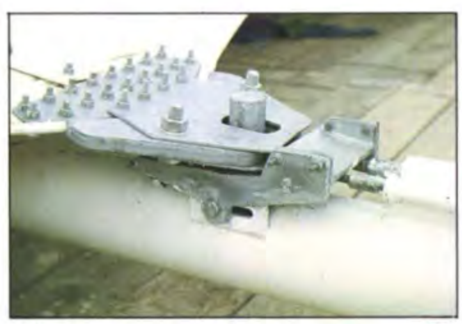

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Fabric roof

The idea of a fabric roof over the upper promenade was an essential part of the competition design. The architect was interested in its quality of translucence while providing shelter against rain and sun; there was also the association with summer marquees around the village green.

The competition scheme had the fabric supported from underneath by steel frames on the 3.66m grid. Three of the 18.3m bays were raised to give a rhythm to the profile and reflect the Grandstand opposite.

However, when the design of the roof began in earnest a year later it was thought that this first idea could be improved. The main objections to it were the quantity of steel needed for the frame system and the way this was immediately below the fabric. These spoiled the floating quality which the fabric needed if it was to seem like a canopy rather than a roof.

Eventually a new scheme was conceived in which the roof was picked up in a series of cones on the 3.66m grid along the spine. the pickup was by cables from the top of masts which projected above the roof on the 18.3m grid. The actual pickup was made by means of a steel ring which spread the load into the fabric. The front of the fabric was attached in 3.66m scallops to catenary boundary cables held out from the masts by booms. Fabric at the rear was held by frames projecting up from the rear girder on the 3.66m grid.

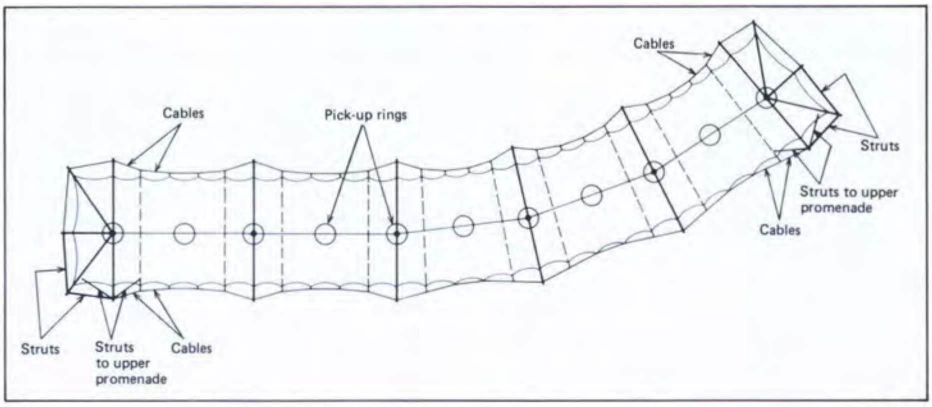
Tender prices for this roof were too high so it was simplified to save money. The fabric tailoring and hardware for each pickup were quite expensive so the idea of the pickups directly relating to the 3.66m box module was abandoned and the number of pickups reduced. The number of rear frames was also reduced so that they only occurred on the mast lines (Fig. 13).

This simplification undoubtedly improved the appearance. Reducing the number of rear frames has lightened the appearance while giving a better visual hierarchy and strengthening the 18.3m grid; the simpler profile to the fabric has given it better proportions from inside and out. This is a good example of how cost cuts can be the catalyst needed to give a design its final refinement.

The finished scheme consists of masts on the 18.3m grid with booms to front and rear.

From the top of the masts, which project above the roof, cables support fabric pickup rings at column positions and at midspan.

The front and rear of the fabric are attached in 3.66m scallops to catenary boundary cables which connect the boom ends. Valley cables pass over the fabric from the front to the rear catenary between the pickup rings and pull it into a shape with the curvature needed in these areas. The front booms are tied down by cables to the front of the upper promenade while the rear booms are connected to triangulated frames which project



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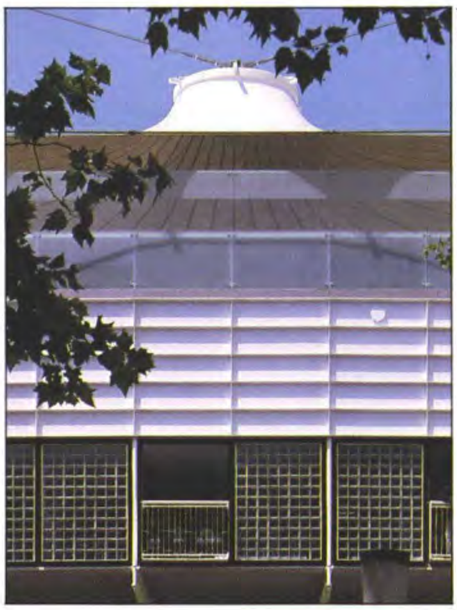

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6. The roof from the west
7. Rear elevation showing all the layers and the braced rear frame
8. The end of the roof
9. End bracing during construction
10. Main fabric/boom connection detail
11. The lower promenade before casting the topping
12. Detail of the rear elevation
13. Plan of rear frames and mast lines
14. The upper promenade
15. The west end with the lift shaft and stairs
16. The rear elevation showing the new brick arches

Photos:

6, 7, 8, 12: Richard Bryant

9: Ove Arup & Partners

10, 11: Harry Sowden

14, 15, 16: Peter Mackinven

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16▽

up from the rear girder. These rear frames resist transverse forces from the wind and out-of-balance loading. They must also resist the overall force towards the pitch caused by the longitudinal tension in the fabric passing around the curve.

The ends of the roof are held out by booms radiating from the end masts and tied together at their ends. Thus all the booms are connected around the perimeter. Lazy cables from the mast heads support the ends of the booms if the fabric should fail.

The longitudinal tension in the roof is resisted by end frames which cantilever up from the ends of the spine beam.

The boundary cable becomes a steel tube between the end frame and the braced rear frame in order to prevent the end frame swinging sideways with consequent loss of stability for the masts in the event of fabric or cable failure in the front of the roof.

All the steelwork joints are pinned apart from those at the base of the masts. This allows the structure to change its geometry as necessary to maintain equilibrium under changing load. However, the rear frames at the ends are restrained from swinging by pairs of push-pull tubes. These frames form the anchor points without which the roof would be unstable.

Cables linking the tops of the masts and continuing down to the end frames resist out-of-balance loads between bays and give an alternative load path should the fabric or its supporting cables fail.

The fabric is PVC-coated polyester treated with PVDF on the upper surface to improve durability. It was to have been *Teflon*-coated glass-fibre because of its durability and property of self-cleansing but this was effectively ruled out during the design period by government authority concern over its toxicity in fire.

An alternative which promised similar durability but without the self-cleansing property was silicone-coated glass-fibre. However, a marketing agreement gave UK rights to a single company and the price was too high.

PVC fabric had originally been rejected because of its limited life but it was found that the cost of a PVC roof was low enough to allow it to be replaced in 15 years and still cost no more than a silicone roof. There is the benefit that materials and prices will probably improve over this period.

Site work

The spine and rear beams are joined on the 18.3m grid while the front and rear ribs are separate elements except for those at the ends and on the column lines.

The main steelwork was erected using a mobile crane operating from a track laid on the pitch in front of the stand. The sacred turf was, of course, removed first. We were told that when this was done during the erection of the Warner Stand the groundsman thought the compaction improved the pitch.

The pitch had to be relaid before the roof was erected. Erection was done by lifting from paved areas within the ground and St John's Wood Road. Once the steelwork was in place a platform was constructed over the upper promenade which assisted the work of erecting the fabric roof while allowing tiling and the fixing of balustrades to carry on underneath.

The roof came as seven panels, one for each 18.3m bay and two end panels. They were joined by aluminium clamp plates. The final erection was carried out by fixing the boundary points and then pulling the rings up to the correct level. All the cables and boundary tubes were provided with adjustment as were most of the fabric attachment points.

GENERAL

Services

The stand is used on only a few days each summer and is more of a shelter than a building. This means that the normal problems of insulation do not occur; it also means that the services are minimal. Mechanical extract is provided to the kitchens and toilets but the boxes are naturally ventilated by grilles into the void above.

Fire

As a result of the fire at the Bradford football ground in May 1985 it was anticipated that Lord's would become a designated ground. The main effect of this, from the engineering point of view, was an increase in the handrail loadings to the point where in some cases, in both phases, it was difficult to carry the loads back into the supporting structure. There was also a general increase in the level of concern shown by the authorities in all aspects of fire.

The minimum of fire protection was applied to the steelwork both to limit costs and to preserve the clarity of appearance. Fire engineering techniques were used to show that protection was unnecessary for most of the steelwork exposed to public view. Of this only the columns, hangers, part of the tie-downs and the beams and columns in the Phase 1 bar have been protected. A variety of techniques has been used depending on the situation.

Wind

Advice on the effects of wind on the stand was given by Tom Lawson of Bristol University. It was important, visually, that the back of the stand should be open and also that the proportions would give good ventilation without draughts at both terrace and upper promenade levels. The terrace is completely open while at upper promenade there are glass screens which leave a 0.5m gap under the fabric. The summer so far has hardly been a proper test!

Credits

Client:
Marylebone Cricket Club
Architect:
Michael Hopkins and Partners
Structural and services engineers:
Ove Arup and Partners
Quantity surveyors:
Davis Belfield and Everest
Management contractors:
Higgs and Hill Management Contracting Ltd.
Structural steelwork:
Claus Queck
Fabric roof:
Koitwerk Herbert Koch

Competition entry:
February 1985
Appointment of design team:
March 1985
Appointment of management contractor:
July 1985
Start on site Phase 1:
16 September 1985
Finish on site Phase 1:
6 June 1986
Start on site Phase 2:
15 September 1986
Finish on site Phase 2:
17 June 1987

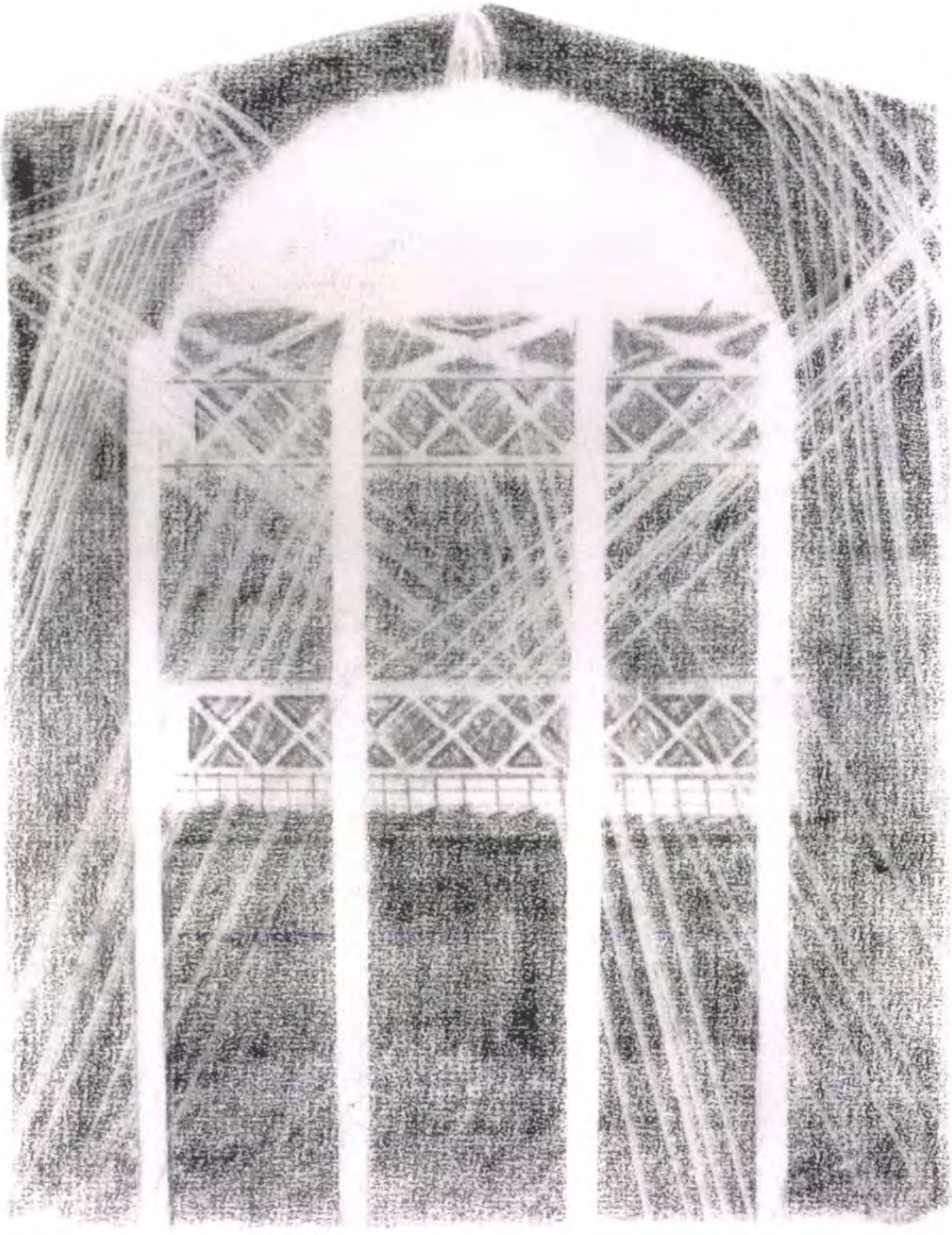
17. View from H stand
(Photo: Richard Bryant)

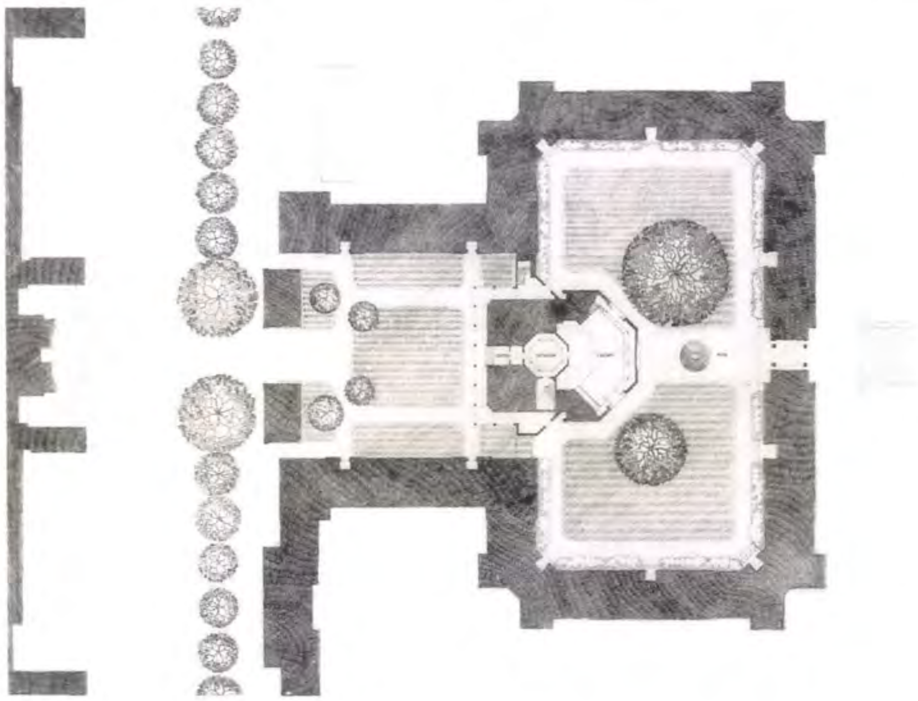
Clare College Library Cambridge

Clare became, at the end of the 17th century, the first college in Cambridge to build a modern library. Before then the books were held in huge oak *classes* in a chamber above the old chapel. A new library was included in the rebuilding of the north range of Old Court (1683-1693). We cannot be certain when this library was ready for use, but in 1742 the Cambridge antiquary, William Cole, wrote of it:

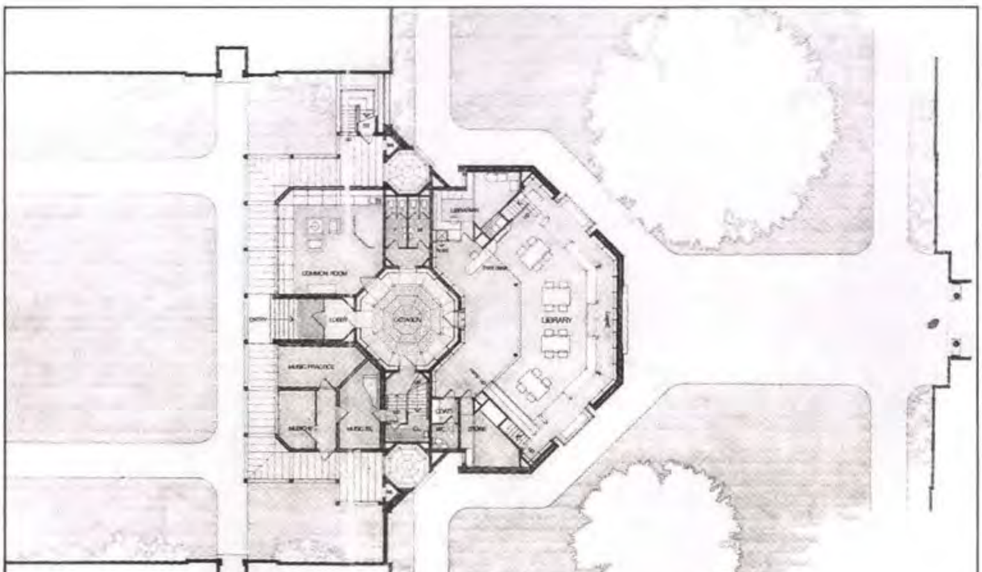
'This Library also is y^e^ most elegant of any in y^e^ University being a very large well-proportioned Room à la moderne, w^th^ y^e^ Books rang'd all round it not in Classes as in most of y^e^ rest of y^e^ Libraries in other Colleges . . .';

the point of such a design being that it left a spacious, comfortable and well-lit working area in the centre.





Block plan



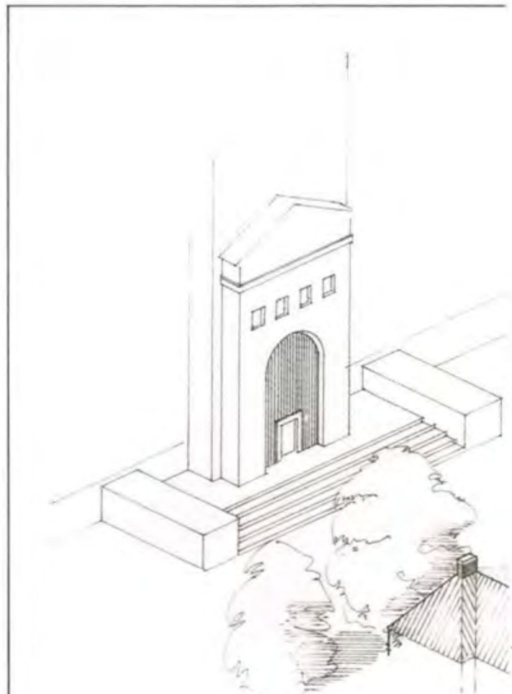
Ground floor plan

First floor plan

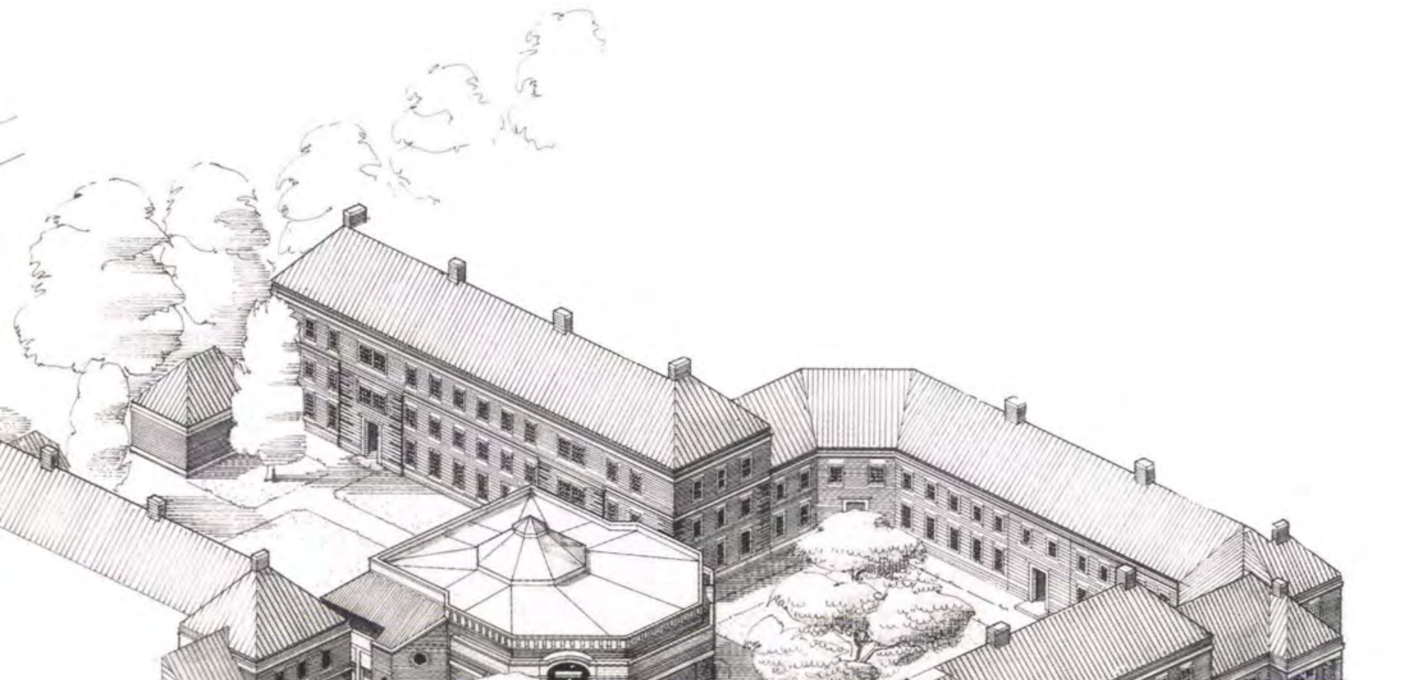
But by the end of the last century Clare had fallen behind; this library had increased immensely in value, but in inverse ratio to its utility, and was not in any case intended for undergraduates. By the time he came to commemorate the College's 600th anniversary in 1926, Mansfield Forbes, while celebrating the treasurers of the Fellows' Library, was obliged to regret the College's failure to make proper provision for its students. 'What then is needed?' he asked:

'Surely, it is, in every college, an up-to-date and intimately accessible students' library, for easy loan and ready reference, where essays could be excogitated . . . In most Cambridge colleges such libraries exist, and are in constant and effective use. Clare lags ignobly, and does not deserve the treasures we can hardly house or care for decently. May we hope to say, before 1930, nous avons changés tout cela?'

At his death in 1935 Forbes left his own collection of books to the College, in effect creating the undergraduate library. In its cramped quarters between D and E staircases, with the books again held in free-standing cases (first of oak, later of steel), the Forbes Library, helped by skilful rebuilding and restocking, served the needs of Clare students for more than 30 years. But by the mid-1970s it had been pushed to the limit of its capacity. Two surveys in the academic year 1978-79 brought before the College the fact that Clare's undergraduate library had become, in every respect, among the very worst in Cambridge.



Bird's eye view

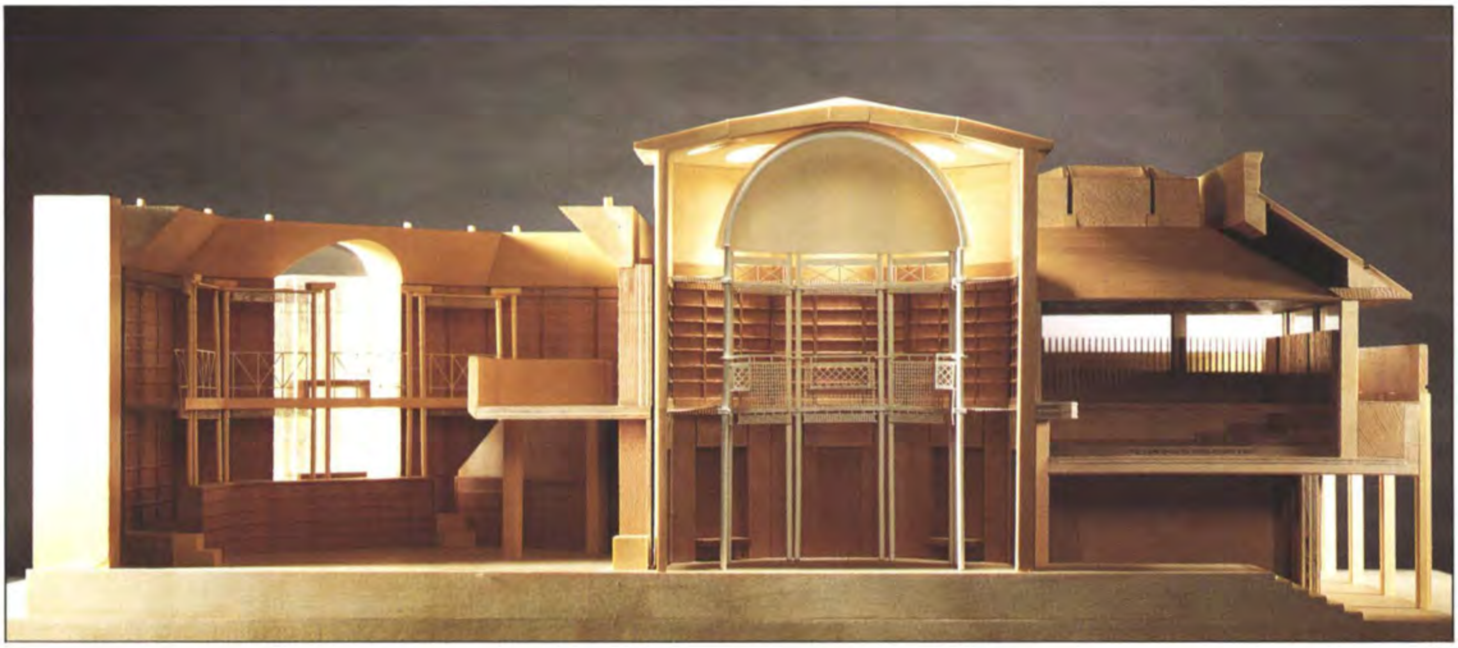


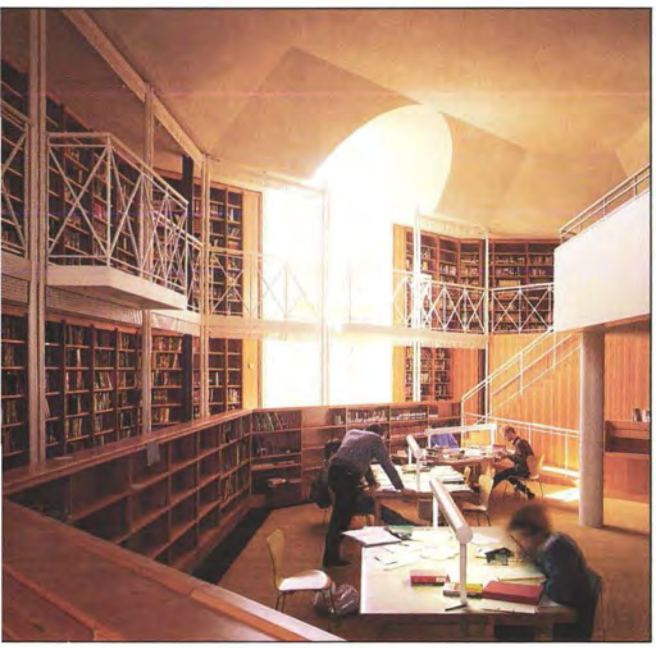
By this time enlarged library facilities were not our only need. Apart from the founding of Clare Hall in 1966, the most important development of the College since the last war was the admission of women in 1972. Among other remarkable effects, this led to the creation of a mixed choir, and, under the inspiration of three gifted Directors of Music, a large number of singers and instrumentalists had been attracted to the College and brought Clare music to a prominence rivalling that of colleges whose musical establishments were far more richly endowed.

Reviewing its position in the academic year 1979-80, the College concluded that the most pressing needs were for a new undergraduate library, facilities for musicians, and support for the research students whose numbers were growing in consequence of Clare's tripos success. Therefore, in the autumn of 1983, the College launched the Thirkill-Ashby Appeal, with the object of raising £1.25M for the purpose of housing an enlarged Forbes Library, a recital room, and music practice rooms.

The College was able to engage the services of Sir Philip Dowson (Clare 1947) of Arup Associates. The brief was to submit a design for the accommodation of the library and music facilities on the Memorial Court site, preferably within a single building. The building was to be as modern in style and function as consistency with the existing architecture of Memorial and Thirkill Courts would allow. the Governing Body accepted Sir Philip's design, and was able to announce, early in 1984, that the generosity of members and friends of the College made it possible to seek tenders for the building. Messrs. William Sindall Ltd., an established and respected Cambridge firm, began work on the site in July 1984, and the building was opened for the use of students at the beginning of the 1986 Easter Term.

On a small site the architects have, with no sense of constriction, included not only the library and properly-insulated music facilities, but a common-room, a photocopying room, and a computer room as well. The building stands in the centre of Giles Gilbert Scott's original court, but with such respect for the surrounding architecture that it seems not to intrude on Scott's design, but to complete it. The Octagon at the centre of the building is reminiscent of the beautiful 18th century octagonal antechapel in Old Court, and, once again, as in the Old Fellows' Library, the books in the new library are ranged back against the outside walls, leaving a spacious and well-lit working area at the centre.





The building marks a new development in the life of the College. At a stroke the two main criticisms of Scott's design felt by Clare people have been removed: the domestic scale and function of Memorial Court no longer serve merely as a triumphal approach to the University Library, and Memorial and Thirkill Courts no longer seem dormitory suburbs of Old Court.

The introduction of important facilities into the Memorial Court has brought about a coherent and integrated expansion of the College's corporate life. Sir Philip Dowson's design is a tactful addition to the unpretentious architectural beauty which we have inherited from the past, even as the practical functions which it includes mark the College's continuing commitment to the needs of its present and future students.

Dr. Richard Gooder, the author of this article, is Forbes Librarian and a Fellow of Clare College.

Arup Associates
Architects + Engineers + Quantity Surveyors

Photos: Martin Charles: p.9 (top), p.11 (bottom left & right), Ben Johnson: p.11 (top), George Perkin: p.12 (left), Arup Associates: p.10 & p.12 (right) Illustration p.9: Ben Johnson

Salford Quays

David Johnston
John Morgan
Roger Wood

Introduction

The General Election, and subsequent Queen's Speech, has focussed attention on the plight of the inner cities in Britain and created considerable debate on how to tackle the problem. A variety of different initiatives are either under way or being proposed, most of which are in the embryo stage. Meanwhile in Manchester over the past two years construction has been proceeding at an accelerating rate in Salford Quays where a totally derelict inner city site is being reborn.

Historical background

In the last quarter of the 19th century, industry and commerce were moving from Manchester towards Liverpool to take advantage of the port facilities. The burghers of Manchester responded to this challenge by financing the construction of the Manchester Ship Canal and port facilities. The largest element of the port was the four finger docks in Salford. This massive project, despite various engineering and financial problems, was ultimately successful and both Manchester and its port flourished to become one of the most important cargo ports in Britain.

Trade peaked in 1958 when 18M tons were handled. Economic changes, increased size of ships and failure to respond rapidly enough to new handling techniques led to a steady decline and Salford Docks were closed in 1984.

Context and origin of Salford Quays project

Salford Quays lies 3km from the centre of Manchester. Road communications are good, the national motorway network being reached in five minutes.

The immediate hinterland of the site is unpromising, carrying all the hallmarks of urban decay and loss of confidence. Across the Ship Canal is the Trafford Park Estate, once the largest industrial estate in Britain but now a desultory shadow of its former glory. To the east there is a mix of post-war municipal housing and industry. However, signs of new hope were being seen in the enterprise zone to the north and in its small triangular appendage in the southern corner of the site. In the large northern sector, light industrial and warehousing buildings were being developed by the private sector strongly encouraged by the City of Salford. The first attempts to redevelop the docks arose from private sector interest in the small southern part of the enterprise zone.

This interest was prompted by the enthusiasm and vision of Peter Hunter of Shepheard, Epstein & Hunter. Although some limited advances were made, the scale of the problem was too great and it was the purchase of the majority of the site by the City Council in 1984 which signalled the real start of the redevelopment. The City commissioned Shepheard, Epstein & Hunter who were assisted by Ove Arup & Partners, to prepare an Infrastructure Development Plan.

Development plan

The site is triangular formed by the convergence of the Ship Canal and Trafford Road with the southern boundary of the Enterprise Zone providing the base.

The total area is 60ha of which one-third is water. The dock basins range from 256m to 823m in length and 68.5m and 76m in width.

1△

1. The docks in their prime: No. 9 dock, July 1953 (Photo: Elsam, Mann & Cooper. Reproduced by courtesy of the Manchester Ship Canal Co.)

2. The site before development

3. Location of Salford Quays (Reproduced by courtesy of Shepheard, Epstein & Hunter)

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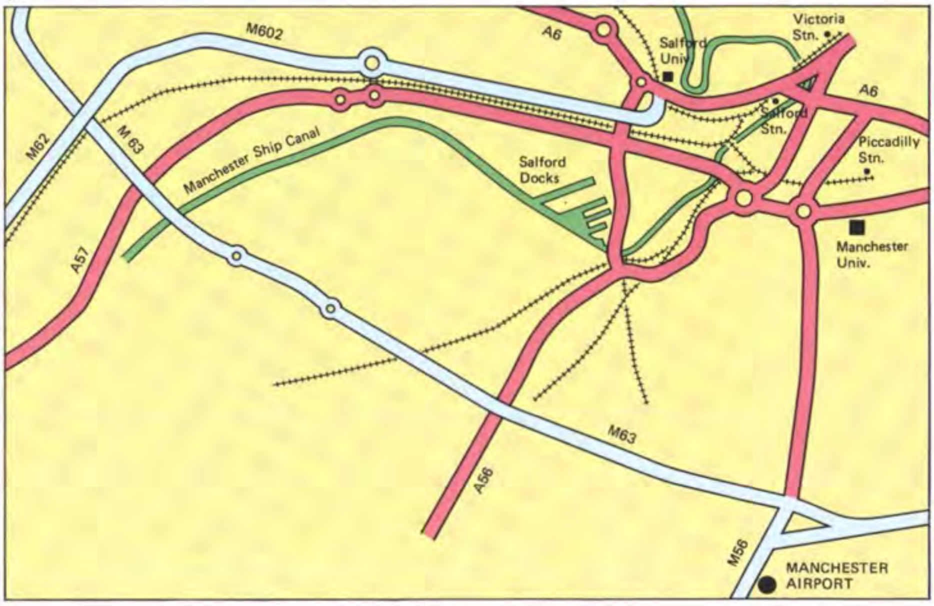


The site is flat and was devoid of any structures of merit save the massive grandeur of the dock walls themselves and a disused swing bridge. The major asset was the presence of water which, conversely, was the source of two major problems. Firstly it is highly polluted and secondly it separates the developable land into long unconnected fingers.

The Development Plan saw these problems being overcome and the water asset optimized by the construction of bunds across the three major basins, which at once united the land and allowed the impounded water to be treated. A single lock would connect the internal water to the canal and the three basins were to be interconnected by two canals. These canals would not only allow boat movement between the basins, but also extend the valuable water frontage, and with their bridges introduce a third dimension into a flat site.

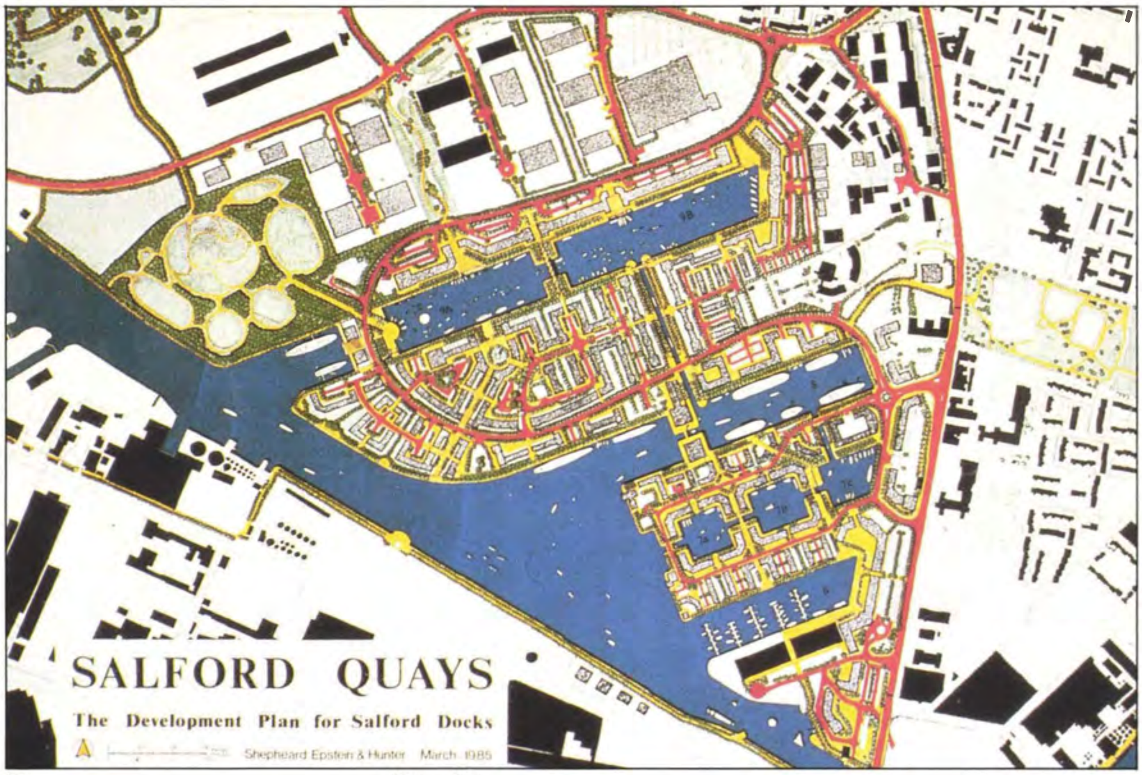
The 93m long swing bridge is to be relocated across the longest basin to form a pedestrian link and general amenities area.

The landscaped straight bunds, canals and dock walls, together with the sinuous road network, form a strong framework for development. The land parcels created provide a wide choice of shape and size for developers.

4. The Development Plan (Reproduced by courtesy of Shepheard, Epstein & Hunter)

5. Limpet coffer dam

6. Service duct under construction (Photo: Ove Arup & Partners)



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The plan foresaw progressive implementation from Trafford Road to the end of the piers. Besides limiting expenditure on infrastructure in the early stages, this strategy allows the development to grow from the existing urban fabric and for each stage to be a complete entity rather than an isolated pocket set in a building site.

Funding

A fundamental objective of the Development Plan was to attract both private and public funding for the development. The City of Salford's basic tenet was that the project was a partnership between private developers, the City of Salford and Central Government. The civil engineering works were to be grant-aided, the majority coming from Derelict Land Grants with contributions from the Urban Programme and European Regional Development Fund.

A number of aspects of the plan, such as the new canals and the relocation of the swing bridge, were unusual elements in grant applications. Fortunately the North Western Office of the Department of the Environment appreciated that the creation of exciting and high quality infrastructure was necessary to attract private investment.

A major breakthrough was achieved when the Department determined that a three-year rolling programme of grants would be made with an eventual spend of £25M over five years. This enabled a design and construction programme to be initiated and inspired confidence in the business community.

Arup involvement

The Development Plan was approved in late spring 1985, and in late summer Arups were appointed as consulting engineers for four contracts which would be added to if the development were successful. In the event, the project rapidly attracted private investment and enabled Salford to obtain a substantial share of Central Government grants. By the summer of 1987, Arups had received 45 separate commissions covering a wide variety of design and investigatory works and had 11 site staff supervising 10 construction contracts.

The principal elements of work are:

(1) Roadworks, drainage and public utilities
(2) Formation of bunds, new dock walls and lock
(3) Canals, road and foot bridges
(4) Relocation of the swing bridge and cranes
(5) Monitoring of water quality
(6) Water treatment equipment
(7) Lighting to public areas and water
(8) Hard and soft landscaping
(9) Preparation of ground for developments.
(10) Filling of underground ducts.

Arups are the prime agents for all public sector works with the exception of the initial soft landscaping contracts. We have employed ASH as subcontractors on the subsequent landscaping works. Throughout the project there has been close co-operation with the City of Salford and their consultant architect Shepheard, Epstein & Hunter. The latter has not only had the task of co-ordinating the planning and urban design of private and public works, but has undertaken the concept design of hard and soft landscaping.

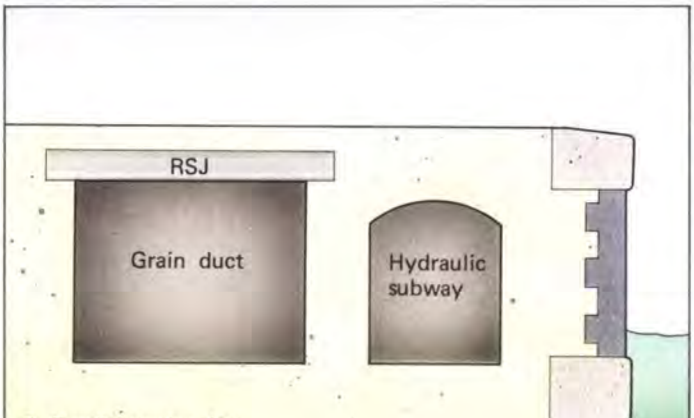
Design and construction co-ordination

The individual projects have offered their own problems and challenges but the co-ordination of both design and construction of the multiplicity of separate contracts has been a major generator of activity.

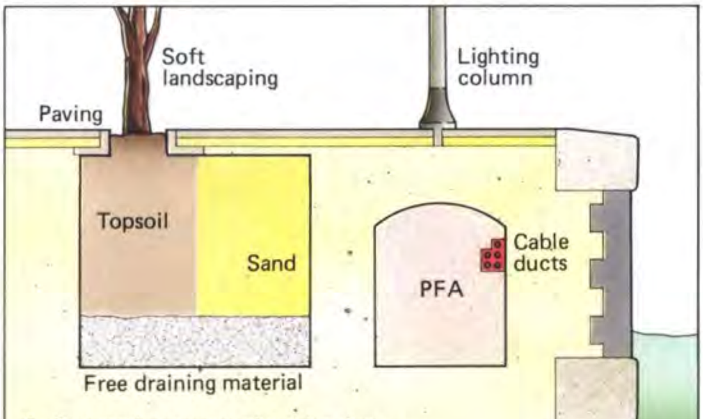
Two forces drive the programme, the demands of the private sector developments and the release of Central Government funds. The former changes both the timing and form of development according to the market. Although part of a rolling programme, the timing of the release of funds depends on private sector commitment and the size and type of grant required.

Under the circumstances, often the most obvious selection of the contents of a construction project and the desirable relative timing of related projects have not been achievable. The bridge over the first canal was designed and built before the canal, separate contracts have been let for roadworks and associated landscaping and accesses to proposed developments moved.

On site a primary issue has been the logistics of running simultaneously a number of often geographically overlapping public sector-funded and private sector construction con-

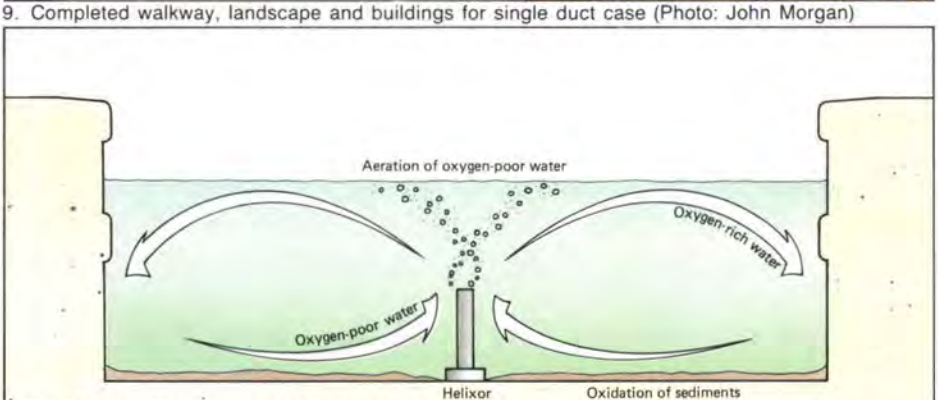


7. Derelict service duct



8. Proposed treatment of service duct

9. Completed walkway, landscape and buildings for single duct case (Photo: John Morgan)



10. Water quality improvement: principle of aeration

tracts, and endeavouring to keep construction traffic off new roads and distant from completed buildings. Because development commenced from Trafford Road, which was the only access at present to the site, the problem becomes more acute as construction approaches the end of the piers.

Canals and bridges

Of the two canals suggested in the Development Plan the canal across Pier 7 is now open and the one across Pier 8 is under construction.

The Pier 7 canal which is 80m long is crossed by a road bridge. The need to provide early access to the private sector developments on the pier required the bridge to be constructed in advance of the canal. The canal is 7.2m wide and 2m deep and is flanked at some 600mm above water level by 2.8m wide walkways. At the ground level, some 1.7m higher than the canal, there is another pair of landscaped public paths.

The bridge rises 2.5m above grade to provide a 3m airspace for boats.

The finishes have been designed to a high quality and match the materials used for the existing dock walls. The walls are of blue engineering bricks with granite copings and the walkways are finished with red clay pavers. The railings and lighting columns are cast iron painted black.

The canal was constructed in the dry by damming the end with limpet coffer dams. Canal and bridge were completed on schedule in seven months.

The canal across Pier 8 uses similar materials but is larger in scale being 230m long, 10m wide with flanking landscaped walkways 7.5m in width. It will be crossed by a road bridge and three footbridges.

In this instance the bridge and canal are being constructed simultaneously, although under two different contracts. The dock wall at the northern end is of an arched construction similar in elevation to a railway viaduct; the retained fill slopes down through the arches protected by a rock blanket. This has required a different construction approach to be adopted; sheet piles have been driven to form a coffer dam while the existing walls are demolished.

Service duct

Concrete and brick arch service ducts, 1.5m high and 1.2m wide and 1.5m high and 3m wide, ran behind the entire length of the dock walls on Dock 9. The ducts were structurally unsound and constituted a health hazard. Being remote from the central access roads on the piers, the potential use as ducts for new services was very limited. This potentially negative feature of the site has been turned to advantage by using the ducts for quayside tree planting, with a public walkway on top; they also carry electrical feeds to the footpath and dock wall lighting. The trees are planted at 8m intervals with cast iron lighting columns at 8m intervals; the walking surface is composed of brickwork paving.

Three interrelated design issues were the supply of water to the trees, the drainage of the duct and the need for access into the duct to renew services and replace trees.

The bottom of the duct was filled with free draining material to a flood level and then capped with a layer of PFA to accommodate changes in dock water level which threatened to drown the tree roots. The remainder was filled with topsoil which was drained by a perforated pipe into the Ship Canal, rather than into adjacent dock water to prevent nutrients entering the impounded basins.

The roofs of the ducts were removed at tree pit locations, and the walls built up. On top of the concrete, brick pavers were laid to fall into a central line of perforated pavers.

Improvement of water quality

The water quality in the impounded basins needed to be improved to a level where it appeared attractive and allowed water sports to be enjoyed in safety. The construction of the bunds prevents polluted Ship Canal water entering the basins in any significant volume, thus providing the opportunity to treat the impounded basins separately.

A programme of sampling established that the main cause of pollution in the upper reaches of the Ship Canal was the discharge of partially treated sewage which produced excessive nutrient levels, bacterial populations and organics loading. Once impounded and still, the water would stratify into a warmer upper layer, through which sunlight would penetrate, and a cooler layer below. In the upper layer algae could bloom, forming an unsightly green carpet. The blooms would then decay and drop onto the silt consuming the little oxygen that exists. The result would be anoxic conditions with consequent production of methane and hydrogen sulphide gases from the breakdown of organic compounds in the absence of oxygen. During certain climatic conditions the stratified layers invert and the gases and black decayed material come to the surface.

To prevent these hazardous conditions developing, it was decided to install helixors into the basins. Compressed air is pumped through a diffuser into the helixor giving a circulating cone of bubbles which mix with and draw up water from the bottom. This water spreads out over the water surface picking up substantial amounts of oxygen. On meeting the dock walls this oxygenated water is deflected downwards. This cycle breaks down the stratification, bringing oxygen to the bottom and preventing formation of noxious gases. Eventually the upper level of the silt will be oxidized into a crust, thus sealing in the contaminants in the silt. The helixors were installed in July 1987 and sampling has shown an improvement in water quality and diversity of the ecology.

11. Chandlers Canal and steps (Photo: John Morgan)

12. Completed canal and bridge (Photo: John Morgan)

Conclusions

The first civil engineering construction contract was commenced in 1985 and seven major contracts have now been completed. These include the bunds across two basins, the first canal, quayside walkway and landscaping and the roadworks, canal bridges and utilities giving access to the first two piers. The target expenditure for 1986/1987 of £5.25M was achieved and we are on programme to meet the £8M expenditure for 1987/1988.

The pace has been set by the private sector's interest which has seen the opening of an eight-screen cinema, a 166-bed hotel, a high technology office block and the occupation of the first apartments and houses. Our first resident was from the cast of Coronation Street. Currently under construction are further office blocks and two housing projects.

The project has called on a wide range of disciplines and considerable flexibility of working to accommodate the changing programme. The rewards are now there to see not only in physical terms but in the renewal of confidence. No longer at Manchester's Piccadilly Station does a taxi driver question why you should want to go to the docks but will quite possibly show you a video of Salford Quays.

Credits

Client:
City of Salford

Co-ordinating architects, landscape architects and planners:
Shepheard, Epstein & Hunter

Consulting engineers:
Ove Arup & Partners

Landscape architects:
ASH Environmental Design Partnership

13. Aerial view, summer 1987 (Photo: Airviews (Manchester) Ltd.)

Sauchiehall Centre, Glasgow

Architects:
Bradshaw Rowse & Harker

Ivo Lunardi

Introduction

The Sauchiehall Centre was originally completed in 1975, under a separate design team, on a 0·5 ha site in one of Glasgow's principal shopping thoroughfares. The development comprised eight levels including a basement with the lowest three intended for retail use. The top three levels were to operate as an offstreet car park administered by the Regional Council and accessed by external ramps. The remaining levels 4 & 5 were taken up by the service yard, also accessed by the ramps, and storage areas for the shops below.

The site levels were such that access to the Centre was provided directly to level 2 from Sauchiehall Pedestrian Precinct and to level 3 from Bath Street, parallel to Sauchiehall Street.

Despite these advantages the Centre was failing to realise its full investment potential. The reason for this was believed to be the centre's inability to draw shoppers in and around the shops due to its poor provision for circulation and no intervisibility between levels.

An agreement with the House of Fraser, occupying half the lettable area, provided the opportunity, and the space, to undertake an imaginative £4M refurbishment. The dual object; to attract a wide selection of quality retailers, and, to generate a flow of shopper traffic through all three of the Centre's retail levels.

The scheme

The refurbishment's principal theme was to create a central concourse around a new atrium by cutting large voids through both levels 2 & 3. This atrium would contain an angled bank of escalators and a new hydraulic glass lift connecting the three shopping levels. The now vacant area at basement level was converted into a multi-outlet fast food court which would attract shoppers into the Centre and require them to move between levels. To inject night life, a Leisure & Fitness Complex was planned for the empty areas on levels 4 & 5. The complex would be open 24 hours and would be entered from Bath Street, or, by a new lift installed in the level 6 car park.

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1. View of shopping malls around one of the new atrium wells
2. Looking down into the new feature lift well from level 3
3. Bell fountain features
4. Perspective of angled escalator bank

5. New water feature in the basement food court

6. New basement water feature and fountain jetting through three floors

The building's exterior was also improved by reworking the existing feature glazing and providing canopies along Sauchiehall Street and Bath Street. For the latter, columns could not be introduced on the street and the new canopy was cantilevered from the face of the existing structure. Additional shop units were achieved by erecting new two-storey structures along the sides of the Centre, tucked under the car park ramps, giving continuity to the canopy theme.

The interior finishes were improved and all traders were given the opportunity to revamp their shopfronts in line with the centre's new image. Some also took the opportunity to expand and install/remove (or both!) staircases within their demise. Rearranging the layout of units also required corresponding alterations to the servicing facilities which included extending the travel of a goods lift, and, providing new accesses into existing concrete stair towers.

All the public areas were upgraded and finished in polished stainless steel and oak with all architectural details and motifs carried out in the style of Charles Rennie Mackintosh, Glasgow's internationally acclaimed architect.

The challenging factor, however, was that the entire refurbishment had to be carried out while keeping the Centre open to the public and affording existing traders all their normal facilities. And the scheme should have the flexibility to be modified locally to suit new retailers taking space as the contract neared completion.

Design and construction

The existing structure was constructed in reinforced concrete with 400mm thick coffered flat slabs throughout on a 9.5×7.5m grid of 800mm square columns. To form the central well, some 300m^2 of floor had to be cut away by diamond sawing. Large areas had to be cut into man-handleable blocks for removal. Stringent measures had to be taken to contain and dispose of the two gallons of water per minute used on the 1500mm diameter saw. As a result no existing traders suffered water damage even though some were only 2m away from the operation.

The free edges of the floors around the holes were carried on 80 tonnes of framing and support steelwork. Headroom problems helped to inflate this figure as column sections had to be used for beams. Where framing steel could not be supported on existing columns high tensile alloy steel bars were used as tension hangers, leaving the basement area free from additional columns.

The hangers, with an ultimate load of 125 tonnes, supported both levels 2 & 3 and were suspended from a grid of beams at the underside of level 4. To restrict deflections these were installed before floors were cut and then preloaded by jacking against the slab soffit.

The areas outside the central core, while less glamorous, still formed a major part of the refurbishment. In all, a further 80 tonnes of structural steel and over 500 large diameter expanding anchors were used in over 20 'minor' exercises involving structural modifications. Examples of these were supporting the new Leisure Complex lift wholly at level 3, removing a stair well over 5 levels, or, installing over 200m^2 of new suspended flooring.

With the amount of building work required, dust became the biggest nuisance. The contractor eventually had to resort to completely sealing off areas in which demolition was taking place in an attempt to prevent dust spreading throughout the Centre.

A local anaesthetic

In the end this 'live' element became the major aspect of the project, requiring the highest level of integration and communication between the project team disciplines. The whole of the works had to be carefully planned and sequenced to allow occupation and handover of public areas. Temporary accesses and malls had to be built, and finished to a degree that would not deter potential shoppers. To make these temporary areas more interesting, a selection of traders with stalls were introduced which helped give the effect of an indoor market. In addition, windows were formed in hoardings through which the public could see the works in progress. At each window there was an artist's impression which showed a view from that point of what the completed Centre would look like.

Many aspects of the work such as concrete cutting could not be carried out during the day due to the high noise levels. These operations were carried out overnight with the debris removed during the day. Ultimately this resulted in round the clock working with three shifts.

Public relations quickly assumed a vital role for the contractor, as many operations were best carried out with the full co-operation of the retailers. Weekly meetings were set up at which the contractor and Centre Management Staff discussed any problems and forthcoming events with the retailers.

Throughout the project, as various agreements were concluded between retailers and the Centre Management, schemes for modifications to existing units had to be continuously prepared. This resulted in detailed design and working drawings being prepared throughout the contract. Towards the end this activity increased as potential new tenants loomed on the horizon and attempts were made to include last minute alterations within the contract period.

The design certainly wasn't finished 'til the last screw was turned!

The tail piece

The refurbishment was certified practically complete this March, apart from the work to the new under-ramp units. With all the tropical planting now complete, including an exotic Florida Palm imported from the USA, and, the new basement water feature spraying its 10m high fountain through the mirrored floor voids, the Centre's metamorphosis is already creating quite a buzz.

In January, however, just when the project seemed to be drawing to a close, the letting agents confirmed that Top Shop and Top Man were taking four corner units to trade on two levels. The new tenants would require a connecting staircase and a new escalator to be installed: . . . three more holes to be cut; another 12 tonne of steelwork. Suddenly, we found ourselves back at preliminary design and drawing stage preparing a scheme to allow the shops to open for Easter trading.

A year before we would have thought it all impossible!

Credits

Client:
Postel Investment Management Ltd.

Architect:
Bradshaw Rowse & Harker

Structural consultants:
Ove Arup & Partners Scotland

Quantity surveyors:
Tozer Gallagher & Partners

Mechanical & electrical consultants:
Brian Ford Partnership

Management contractors:
GA Group

Letting agents:
Bernard Thorpe & Partners

Photos:
Guthrie Photography

Alhambra Theatre Bradford

Architects:
Renton Howard Wood Levin Partnership

Martin Gates-Sumner

The challenge of this project has been to integrate successfully new extended foyers, back-of-house and stage areas into the existing fabric without disturbing the auditorium, and retaining the distinctive towers and rotunda. The splendour of the original Edwardian auditorium has been enhanced by the installation of new ventilation, lighting and production facilities affording modern standards of comfort and operation for public and performers alike. New rehearsal and amenity facilities have been provided in the adjacent former Majestic Cinema now refurbished as part of this project.

The structure

The need to create efficient, and generous public and production space around the retained auditorium dictated that the limited foyer and stage areas of the old Alhambra should be largely demolished. These have been replaced by new enlarged structures, which together with the construction of backstage areas outside the line of the former Great Horton Road elevation, now envelop the refurbished auditorium. The problems of connecting to the existing structure required careful sequenced construction to maintain the stability of the auditorium enclosure at all times. The Majestic has been refurbished by strengthening the rear balcony and reconstruction of access stairs, allowing public use of this space.

A four-storey reinforced concrete frame forms the new foyers with the floor grid expressed in the coffered ceiling and supported on fairface circular columns. Perimeter columns are enclosed within and provide support to the distinctive aluminium curtain walling. The main features of the existing facade, the two towers and rotunda, have been retained. Substantial temporary works and a strict sequence of working were necessary to carry these roof level structures during construction and transfer load onto their new supports. The Great Horton Road Tower now houses a new lift shaft while the main foyer staircase spirals up inside the rotunda. Precast concrete replicas of the original faience columns support the rotunda dome.

Remodelled vomitory access corridors serving the upper levels are the only structural alterations within the auditorium requiring new columns. The latter are unobtrusively integrated into control rooms at the rear of the stalls. Openings for access between the auditorium and foyer have been reformed at three levels, by inserting large steel frames progressively into the existing brickwork around these openings to transfer loads down through the rear auditorium wall. In addition new means of escape to current standards have been provided by altering or reconstructing existing stairs.

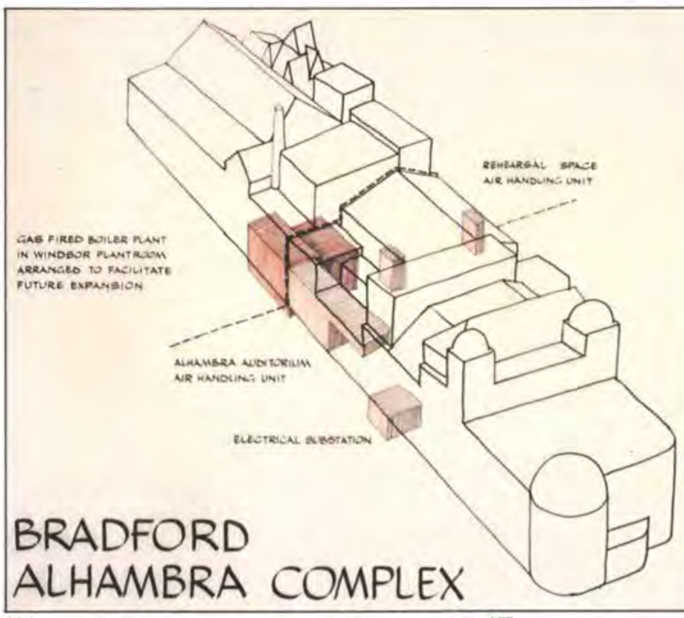
Stage extension

The facilities required by modern large-scale productions demand a far larger stage area than originally existed. To achieve this the rear stage has been extended beneath the adjacent Majestic building. A concrete deep beam spans the width of the stage supporting the rear wall of the new flytower which also forms the new end wall of the Majestic rehearsal space. In order not to disturb the original proscenium wall, new independent columns were introduced to support the flytower roof requiring careful underpinning and temporary restraint of the existing wall.

Services

The existing naturally ventilated auditorium has been improved by the introduction of a mechanical ventilation system, designed to high thermal and acoustic standards to provide a comfortable environment under varying conditions of occupancy. Air-conditioning can also be introduced at a future date, with the possibility of using a heat pump to provide cooling as part of an energy recovery scheme for the adjacent Windsor Baths. Ventilation air is supplied at each level of the auditorium and from high level diffusers sympathetically integrated into the existing domed ceiling. Air is normally extracted at the rear of the seating on all levels, but will cease under an alarm condition when smoke extract operation from the flytower overrides this.

Elsewhere in the theatre natural ventilation has been utilized wherever possible to reduce costs. Separate mechanical systems serve internal spaces such as kitchens and toilets to conform to statutory requirements.



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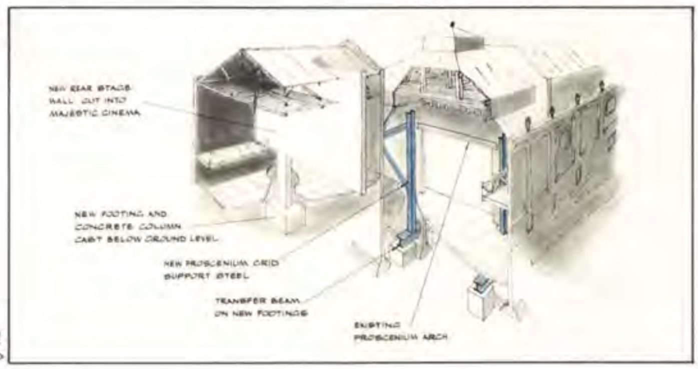

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1. Plantroom locations showing facility for future development
2. Structural principles of extending existing stage
3. Temporary support detail to retained foyer tower

(Illustrations: Beryl Perham)

4. Temporary support steelwork to retained rotunda dome
5. Temporary support steelwork to retained foyer tower

(Photos: Ian Smith)

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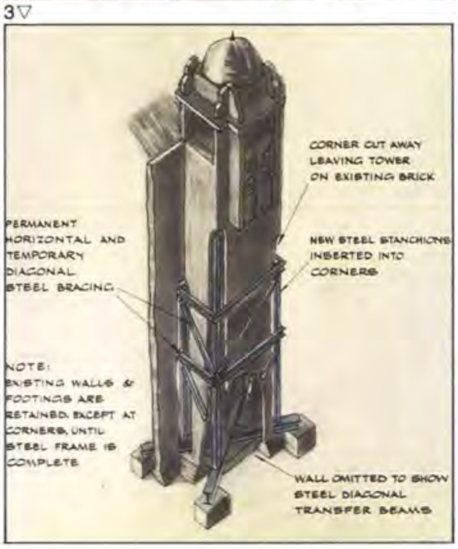

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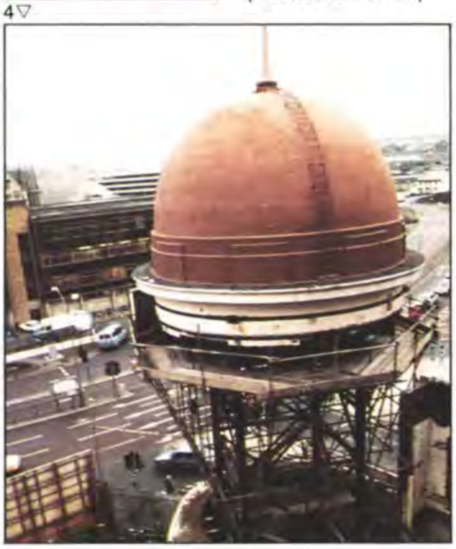

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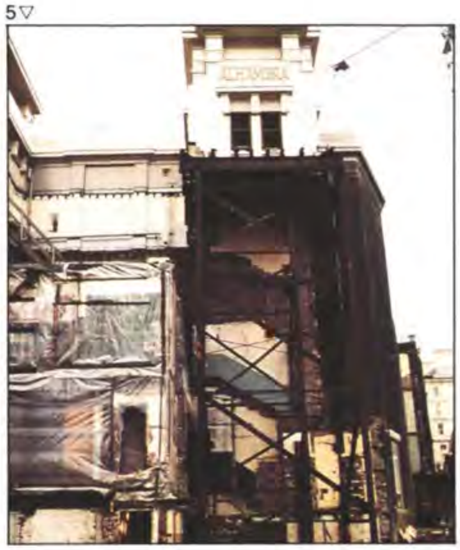


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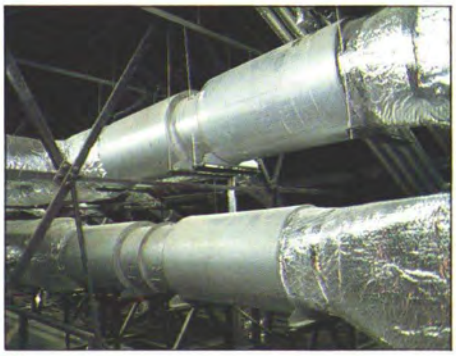
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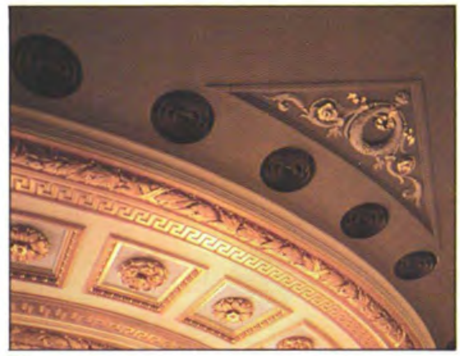
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6. Load testing of existing studio balcony beams

7. New Studio ventilation systems installed in existing roof space

8. Detail of ceiling showing air diffusers

9. Foyer curtain wall and rotunda with new precast column support

10. Great Horton Road elevation showing details of rustication at street level

11. Soffit of main foyer staircase showing recessed lighting

12. Central lighting feature to main rotunda staircase

13. Rotunda stair at stalls level

14. Foyer cornice lighting detail

15. Stalls level foyer with coffee bar mezzanine in background

16. Rotunda precast column detail

17. General view of Alhambra Theatre

18. Stalls level box office

19. Stage door

20. Studio rehearsal space — balcony level

21. Studio façade

Photos:

6: Ian Smith

7, 8, 9, 10, 13, 14, 16, 18, 19, 20, 21 (overleaf 23, 25): Martin Walton

11, 12, 15, 17 (overleaf 22, 24, 26, 27): Harry Sowden

Economic space heating circuits re-using the existing cast iron radiators have been installed to backstage areas, while low level perimeter heating and high level fan heaters are provided in the foyer areas to offset losses through the glazing and entrance doors.

A simply controlled mechanical ventilation system has been installed in the Majestic, designed to cater for a wide range of use and occupancy from rehearsal to public assembly.

Air-handling and boiler plantrooms have been located alongside the Majestic to centralize operation and simplify maintenance. This location also provides the necessary acoustic separation between major plant and the noise sensitive areas of the stage and auditorium. Investigation into the economics of alternative fuel sources led to the selection of gas boilers. A combined boiler capacity of 1700 kW has been installed with the possibility of extension up to 2500 kW in any future redevelopment of the Windsor Baths.

The energy-conscious design, developed to reduce running costs, incorporates careful control of fresh air requirements to the auditorium, and subdivision of heating into six zones with compensated circuits.

New electrical systems have been installed throughout the buildings to offer up-to-date public and production facilities appropriate to a major theatre.

Chandeliers and wall fittings based on the original designs enhance the character of the auditorium, supplemented by dimmer-controlled house and production lighting integrated into the existing fabric of the circle and balcony. In the foyers, special cornice fittings and feature lighting to bars co-ordinate with the interior design, while in backstage areas economic fluorescent installations have been installed. Full primary and secondary maintained lighting systems, complemented by fire fighting and detection installations, provide safe means of escape in an emergency.

Extensive sound and communications systems, essential to the smooth running of a theatre, have been provided throughout, incorporating public address, show relay and calls, and telephones. For the convenience of theatre goers the box office is linked into a central computerized booking facility operating within Bradford.

Power is supplied from a 800 kVA capacity transformer and switchrooms located adjacent to the mechanical plantrooms with separate metering to the Alhambra and Majestic. The stage installations include a specially designed ramped scenery lift connecting with the get-in area, while goods and passenger lifts have been provided backstage and in the foyer.

Credits

Client:
Bradford City Council

Architects:
Renton Howard Wood Levin Partnership

Theatre consultants:
Theatre Projects Ltd.

Structural and services consultants:
Ove Arup & Partners

Quantity surveyors:
Gleeds

Main contractor:
Higgs & Hill (Management)

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